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Spectral Analysis of Field and Armature Currents of Commutator DC Motor

INTRODUCTION

The commutator dc motors are used in industry because of ease of rotor velocity regulation in wide range [3], [4], [7]. Analysis of commutator dc motors with regard to all relevant elements is an important technical problem, since the total cost of the dc motor start up is depending on the ratio between the expenses for the theoretical research and experimental investigation [6], [8]. Experimental investigations were carried out for specially designed dc motor. Construction of this motor permits to investigate the internal asymmetries, e.g. shorting and breaking of rotor coils. Measurement investigations of available signals were aided with computer simulation [1], [2], [5]. Results of spectral analysis of field and armature currents in normal and failure conditions are presented in this paper.

MEASUREMENT INVESTIGATIONS

This motor enables to realize the breaking of one loop rotor coil and shorting of two groups of rotor coils. Each group of coils contains three loop rotor coils. DC machine operating as a motor was investigated in following cases: faultless state, shorting of first group of rotor coils, shorting of second group coils, shorting of two groups of rotor coils, breaking of one rotor coil, shorting of first group of rotor coils and breaking of one rotor coil, shorting of second group of rotor coils and breaking of one rotor coil, shorting of two groups of rotor coils and breaking of one rotor coil. Measurements have been carried out for two manners of armature supplying: from constant voltage source (dc generator) and from rectified voltage source (6T thyristor bridge). Field circuit was still supplied from constant voltage source.
The nominal values of dc machine were: P_N=13 kW, U_N=75 V, I_N=200 A, U_{fN}=220 V, n_N=700 rpm. It was assumed that each group of three loop rotor coils is shorted through resistance R_{bz}=44.2 mΩ. Measurements have been developed by means of 16-bit a/d converter. Considered motor operated in open and closed regulation system. The dc generator connected with external resistance produced the load torque. The additional resistances were used in short-circuits to avoid damage of rotor winding.

SPECTRAL ANALYSIS

Selected results of spectral analysis for closed regulation system are presented in fig. 1-16. Spectral harmonics for constant voltage source supplying the armature circuit are showed in fig. 1 - 8, whereas results for rectified voltage source supplying the armature circuit are presented in fig. 9 – 16. Diagnostic harmonic depends on the velocity of rotor. In figures the following notation was assumed: *n* denotes rotor velocity, f_{diag} – diagnostic harmonic of field and armature current.

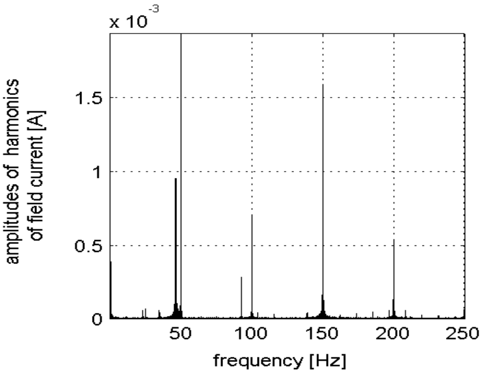

Fig. 1. Spectrum of field current (faultless state)
n = 694.5 rpm, f_{diag} = 46.3 Hz

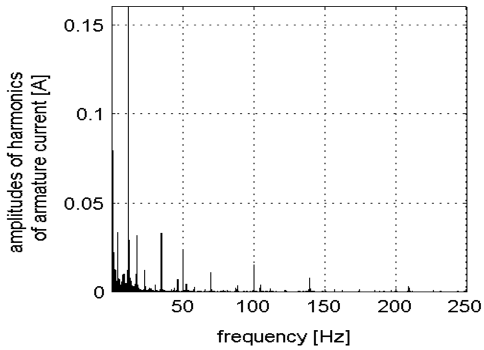

Fig. 2. Spectrum of armature current
(faultless state), n = 694.5 rpm, f_{diag} = 46.3 Hz

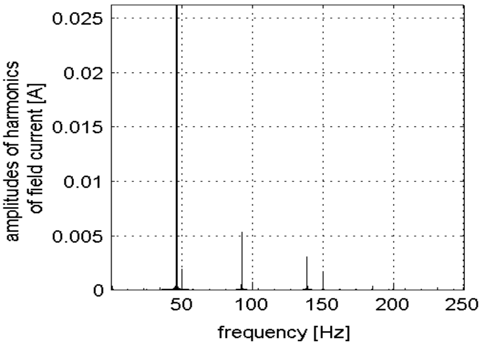

Fig. 3. Spectrum of field current (shorting of three
coils), n = 693.75 rpm, f_{diag} = 46.25 Hz

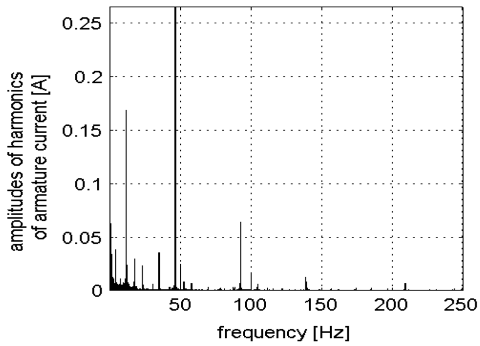

Fig. 4. Spectrum of armature current (shorting
of three coils), n = 693.75 rpm, f_{diag} = 46.25 Hz

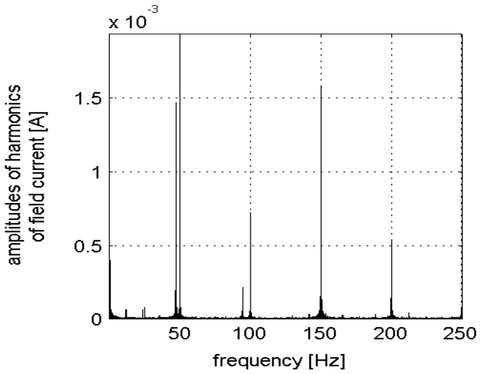

Fig. 5. Spectrum of field current (breaking of one
coil), n = 708.14 rpm, f_{diag} = 47.21 Hz

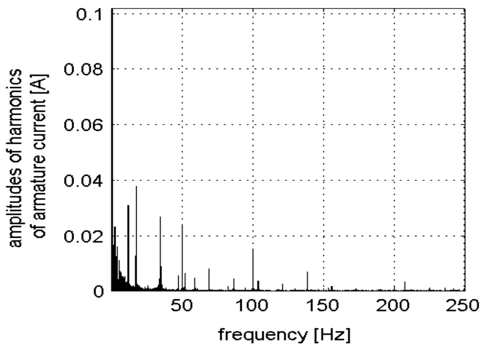

Fig. 6. Spectrum of armature current (breaking
of one coil), n = 708.14 rpm, f_{diag} = 47.21 Hz

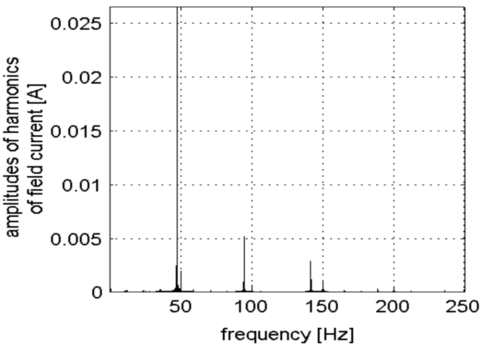

Fig. 7. Spectrum of field current (breaking
of one coil and shorting of three coils)
n = 708.0 rpm, f_{diag} = 47.2 Hz

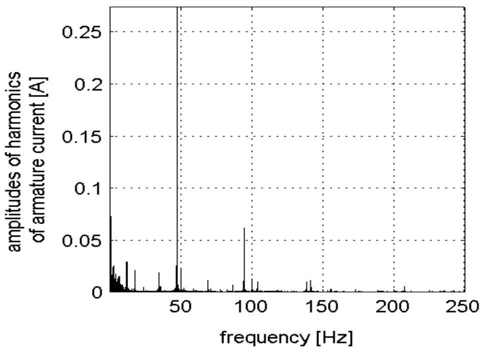

Fig. 8. Spectrum of armature current (breaking
of one coil and shorting of three coils),
n = 708.0 rpm, f_{diag} = 47.2 Hz

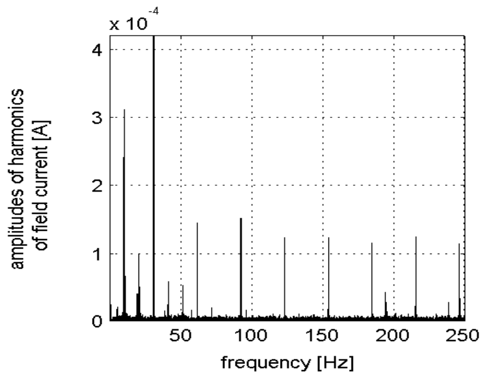

Fig. 9. Spectrum of field current (faultless state) n = 700.5 rpm, f_{diag} = 46.7 Hz

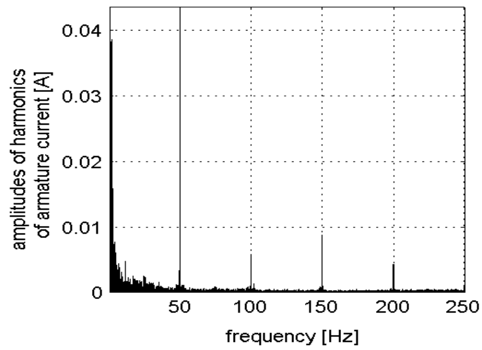

Fig. 10. Spectrum of armature current (faultless state), n = 700.5 rpm, f_{diag} = 46.7 Hz

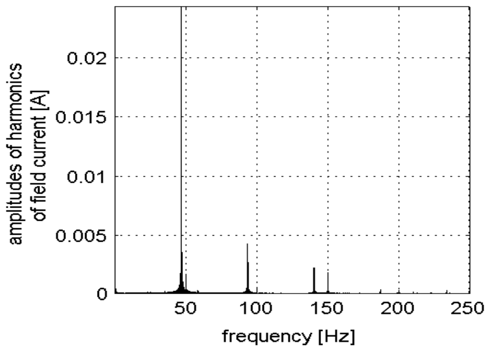

Fig. 11. Spectrum of field current (shorting of three coils), n = 702.0 rpm, f_{diag} = 46.8 Hz

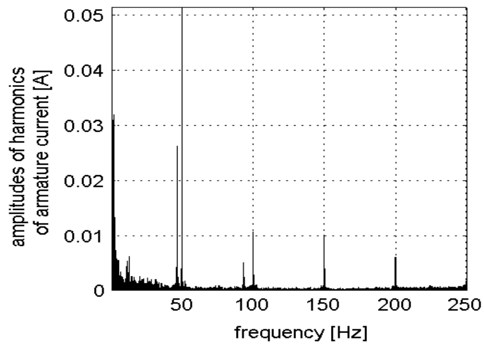

Fig. 12. Spectrum of armature current (shorting of three coils), n = 702.0 rpm, f_{diag} = 46.8 Hz

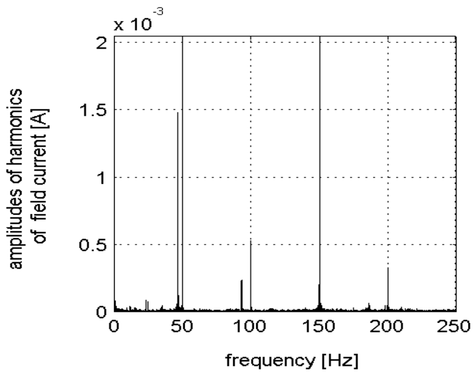

Fig. 13. Spectrum of field current (breaking of one coil), n = 699.75 rpm, f_{diag} = 46.65 Hz

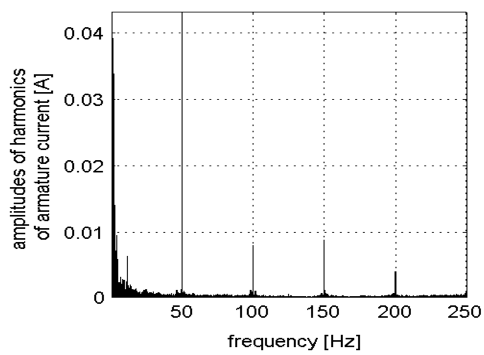

Fig. 14. Spectrum of armature current (breaking of one coil), n = 699.75 rpm, f_{diag} = 46.65 Hz

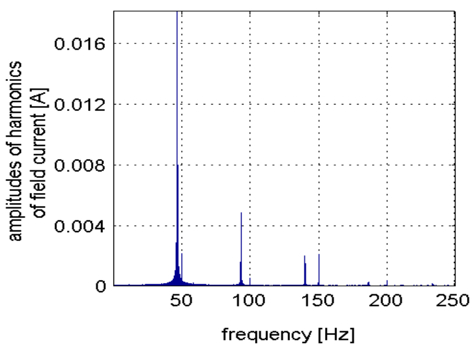

Fig. 15. Spectrum of field current (breaking of one coil and shorting of three coils) n = 700.5 rpm, f_{diag} = 46.7 Hz

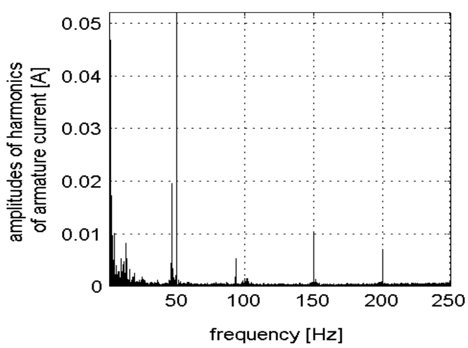

Fig. 16. Spectrum of armature current (breaking of one coil and shorting of three coils), n =700.5 rpm, f_{diag} = 46.7 Hz

CONCLUSIONS

The shorted and broken rotor coils influence on commutator dc motor signals: voltages, currents, electromagnetic torque and rotor velocity. In case of shorting of three or six rotor coils occur considerable deformations of excitation current, armature current, excitation voltage, armature voltage and rotor velocity. In case of breaking of one coil the deformations of mentioned quantities are also visible. Effects of commutation processes can be found in the waveforms of signals. Particularly field and armature currents of dc motor contain deformations which repeatability is closely connected with the velocity of the rotor. Amplitudes of harmonics of field and armature currents in emergency states are several times greater than those in faultless state. Type of supply influences on spectrum of harmonics. For supply from rectified voltage source (6T thyristor bridge) in spectrum of armature current dominates harmonic 300 Hz. Results of spectral analysis indicate that field current and armature current contain diagnostic information and can be used as diagnostic signals. From investigations implies that in remaining motor signals, e.g. in field and armature voltages and rotor velocity is included information about motor state. Because of this reason deep assessment of rotor state requires the taking into consideration several measured signals.

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